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**UNITED STATES DEPARTMENT OF ENERGY
UNIVERSITY CENTER OF EXCELLENCE
FOR PHOTOVOLTAIC RESEARCH AND EDUCATION**

October 23, 2007

Bolko von Roedern
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401

Re: NREL Subcontract #ADJ-1-30630-12
D.5.19

Dear Bolko,

This report covers research conducted at the Institute of Energy Conversion (IEC) for the period of May 1, 2007 to May 31, 2007, under the subject subcontract. The report highlights progress and results obtained under Task 3 (Si-based Solar Cells).

Task 3: Silicon based Solar Cells

In this reporting period, we have correlated the Si surface passivation quality by deposited undoped Si:H films with the silicon heterojunction cell performances in front emitter structure and in the interdigitated back contact structure. The details of the processing parameter variation and the results were reported at the NREL 17th Workshop on Crystalline Silicon Solar Cells & Modules: Materials and Processes (Vail Cascade Resort, Vail, CO, Aug. 5 – 8, 2007) and is attached with this report. The highlights of the result have been summarized below.

Subtask 3.1: c-Si heterojunction device structures using a-Si and related alloys

- Si surface passivation quality of undoped Si:H layer was compared by depositing Si:H layers using RF and DC plasma process and on Si (100) and Si (111) Fz wafers.
- Plasma process of Si:H layer has only a weak dependence on surface passivation quality. The film deposited without hydrogen dilution (defined by $R = H_2/SiH_4$) using DC plasma has a factor of two lower effective minority carrier lifetimes than the RF plasma process. However, lifetimes > 1 msec is achieved using hydrogen dilution ($2 < R < 4$) by both RF and DC plasma process, signifying that there is no adverse effect on surface passivation by apparently higher ion bombardment in DC plasma.
- On the other hand, wafer orientation was demonstrated to have a large effect on passivation quality of Si:H layers. The measured lifetime clearly exhibit a pronounced Si wafer orientation dependence for i-layers grown at $R > 4$. The measured lifetime drops

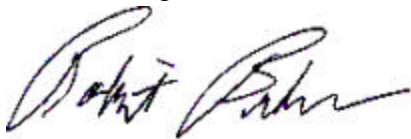
below 10 μ sec on Si (100) wafers, while lifetime remains > 1 msec on Si (111) wafers. An optimum growth condition of i-layer for good surface passivation quality was established, which is independent of wafer orientation and plasma process.

- The c-Si heterojunction cell V_{OC} follows the lifetime values achieved by Si:H i-layers. The lack of surface passivation and low V_{OC} (600 mV) on Si (100) wafers for the Si:H layer grown with $R > 4$ was found to be due to epitaxial growth of Si:H layer.
- Cell Efficiency of $\sim 16\%$ was achieved on polished n-type Fz (100) wafers with $V_{OC} \sim 680$ mV using both RF and DC plasma deposited a-Si:H i-layers.
- Cell Efficiency of 18.8% with $V_{OC} > 690$ mV was achieved on textured n-type Cz wafers using DC plasma deposited a-Si:H i-layers.

Subtask 3.2: Rear Contact/Heterojunction c-Si/a-Si Solar cells

- NREL confirmed efficiency of 11.8% was achieved in an interdigitated back contact Si heterojunction cells, which does not consist any i-layer passivation in the rear and thus results in low V_{OC} of 600 mV.
- Another reason for low efficiency in rear emitter & contact structure was due to low J_{SC} compared to front emitter structure. Low J_{SC} was identified due to complete lack of passivation in the gap between p- and n- strips.
- Incorporation of i-layer passivation in the rear improves cell V_{OC} and J_{SC} but results in “S” shape J-V with low FF. The increase in J_{SC} is due to excellent passivation in the gap of p- and n- strips and high V_{OC} of > 680 mV is due to efficient passivation by i-layer in the emitter and contact strip. Low FF is presumably due to poor carrier transport across i-layer and requires further optimization.

Best regards,



Robert W. Birkmire
Director